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Narrative Review

Regional anesthesia in spine surgery: A narrative review

David S Salven[1]* M.S., David A W Sykes[1]* A.B., Melissa M Erickson[1] M.D., Khoi D Than[1] M.D., Peter M Grossi[1] M.D., Clifford L Crutcher[1] M.D., Miles Berger[2] M.D., Ph.D., W Michael Bullock[2] M.D., Ph.D., Jeff C Gadsden[2] M.D., Muhammad M Abd-El-Barr[1] M.D., Ph.D.

[1]Department of Neurosurgery, Duke University Medical Center, Durham, NC, United States
[2]Department of Anesthesiology, Duke University Medical Center, Durham, NC, United States

ORCID

David S Salven: https://orcid.org/0000-0002-5618-3446; David A W Sykes: https://orcid.org/0000-0002-8154-9921; Peter M Grossi: https://orcid.org/0000-0003-3461-3190; Miles Berger: https://orcid.org/0000-0002-2386-5061; W Michael Bullock: https://orcid.org/0000-0002-8088-8390; Jeff C Gadsden: https://orcid.org/0000-0003-3971-3879; Muhammad M Abd-El-Barr: https://orcid.org/0000-0001-7151-2861

Background

Regional anesthesia, which refers to the use of anesthetics to provide analgesia to a specific body part or nervous innervation territory, has become increasingly popular in the field of spine surgery. With the application of these techniques, it has been postulated that patients will require less systemic analgesia, intraoperatively and postoperatively. The authors of this narrative review discuss the common regional anesthetic modalities applied to spine surgery, in addition to patient selection criteria, success in patients with multiple comorbid illnesses, and its adoption by surgeons.

Materials and Methods

An advanced search was performed in the PubMed database to obtain English-language articles discussing regional anesthesia, awake spine surgery, and postoperative complications. Articles were screened for relevance, and 47 articles were incorporated into this narrative review.

Results

Classic neuraxial and paraspinal techniques have allowed surgeons to perform posterior decompression, fusion, and revision procedures. Transversus abdominus plane and quadratus lumborum blocks have enabled better pain control in patients undergoing surgeries requiring anterior or lateral approaches. Documented benefits of regional anesthesia include shorter operative time, improved pain control and hemodynamic stability, as well as decreased cost and length of stay. Several case series have demonstrated the success of these techniques in highly comorbid patients.

Conclusion

Regional anesthesia provides an exciting opportunity to make surgical treatment possible for spine patients with significant comorbidities. Although additional randomized controlled trials are necessary to further refine patient selection criteria, current data demonstrates its safety and efficacy in the operating room.

Keywords: *Minimally invasive spine surgery, Awake spine surgery, Spinal anesthesia, Regional anesthesia, General anesthesia, Patient outcomes*

Correspondence

Muhammad M Abd-El-Barr, M.D., Ph.D. Department of Neurosurgery, Duke University Medical Center, Durham, NC, United States

Email: m.abdelbarr@duke.edu

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1. Introduction

Regional anesthesia (RA) refers to the use of one of many anesthetic drugs to provide analgesia to a specific body part or nervous innervation territory, typically for surgical procedures or pain management. Unlike general anesthesia (GA), which induces unconsciousness and affects the entire body, RA only affects certain areas, which can allow the patient to remain awake and alert throughout the duration of the indicated procedure. This technique has become increasingly popular in recent years due to numerous advantages such as reduced complication rates, improved recovery times, and superior pain management.

RA can be divided into broader categories of intraspinal, paravertebral, and peripheral techniques. Intraspinal blocks include techniques such as spinal anesthesia (SA) or epidural anesthesia (EA), which provide analgesia to a large area of the body such as the thorax, abdomen, or pelvis. Paravertebral blocks, such as the erector spinae plane (ESP) block, target the paravertebral spaces containing spinal nerves, which can also provide analgesia to a region of the body such as a portion of the chest, arm, back, or leg. Peripheral nerve blocks, such as the femoral nerve block, target specific nerves in the body, and therefore provide the smallest and most targeted area of analgesia. The former two techniques will be the primary focus of this narrative review.

Some fields, such as orthopedic surgery, have adopted the use of RA such that it is now an indispensable contributor to the standard of care. For instance, orthopedists consistently utilize peripheral nerve blocks for the upper and lower extremity alike. Similarly, cardiothoracic surgeons have employed, and, in fact, created some of the most popular paraspinal techniques to provide analgesia to the thorax. Recently, though, there has been an increased interest in utilizing RA within spine surgery.

As RA is a broad term which encompasses the many techniques described above, and more, the authors set out to perform a narrative review describing the different RA strategies that are employed in spine surgery, their indications, and their associated perioperative outcomes.

2. Materials and Methods

A literature review was conducted using English-language articles obtained from the PubMed database with the following advanced search terms: (spine[MeSH Terms]) AND (surgical procedures, operative[MeSH Terms]) AND (conduction anesthesia[MeSH Terms]) AND (postoperative complications[MeSH Terms]). Criteria for inclusion were publication after January 1, 2020, full-text availability, and relevance to the aims of this review. Additional articles were obtained by searching "awake spine surgery." The additional articles were included at the authors' discretion to provide further context where necessary.

3. Results

The primary literature search with the aforementioned terms yielded a total of 51 results. After thorough screening by two independent parties followed by thoughtful discussion, 14 articles were determined to be relevant and selected for inclusion. The identified articles consisted largely of case reports and case series, therefore quantitative analyses could not be performed. A PubMed search for "awake spine surgery" search yielded 22 relevant articles, and an additional 11 articles were included to further this discussion. The findings of the 47 studies included are described in the narrative review in the discussion section.

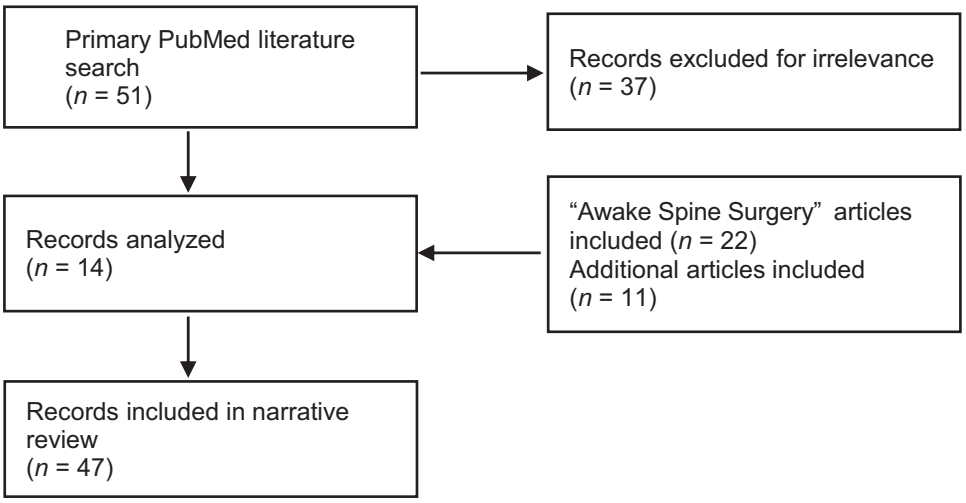

Figure 1. Diagrammatic depiction of literature search and review.

4. Discussion

4.1. Intraspinal regional anesthesia

Several RA strategies, both neuraxial and paravertebral, are available to the practicing spine surgeon. Perhaps the most relevant to this discussion is SA, an intraspinal neuraxial technique used for providing complete anesthesia below a chosen dermatomal level. Several medications are commonly used, each with specific characteristics that influence intra- and postoperative anesthesia when delivered intrathecally. A combination of long-acting bupivacaine with fentanyl is often employed, although some prefer levobupivacaine, as its shorter duration of action may allow the surgical team to perform a more thorough neurological exam postoperatively (1). Patients who undergo SA may benefit from improved hemodynamic stability, decreased postoperative nausea and vomiting (PONV), as well as a shorter length of stay (LOS) in the hospital as compared to patients undergoing GA (1–3). However, it has been noted that patient positioning may influence hemodynamic stability (1, 4). To reduce the risk of complications, an appropriate crystalloid solution may be infused as a means of augmenting intravascular volume (1). Per analysis by Fiani et al., SA appears to be the most commonly employed neuraxial technique when performing awake spine surgery (5).

Although less commonly employed, another intraspinal, neuraxial modality is EA, where medication is delivered above the dural sac, rather than into the subarachnoid space. As the catheter delivering the anesthetic can be left in place, it allows for a longer duration of action, therefore creating an opportunity to perform more extensive, time-intensive procedures, while simultaneously decreasing postoperative opioid use. However, this benefit comes with the consequence of an active catheter potentially interfering with the surgical site. Some elect to use this modality as an adjunct to SA, and many prefer the use of ropivacaine to bupivacaine or lidocaine in these instances. Epidural corticosteroid infusion has also been documented at some institutions to aid in the control of inflammation (1).

Combined spinal epidural (CSE) anesthesia has also been employed and is well described by TM Cook. While this technique has been more commonly employed in abdominal surgery, a case has also been reported of performing lumbar discectomy under CSE in a patient with severe aortic stenosis which provided a barrier to receipt of GA (6).

4.2. Paraspinal techniques

In addition to the intraspinal modalities mentioned, many paraspinal techniques are also available. It is worth noting that these paraspinal techniques seem to be used most commonly in conjunction with neuraxial techniques, rather than in isolation. For example, a "stepwise local anesthesia" approach was described by Wu et al., where local and epidural anesthesia were provided in addition to a nerve root block (7). In some instances, a multidrug injection containing local anesthetics, morphine, epinephrine, and nonsteroidal anti-inflammatory drugs has been used (8). This, however, may not be a necessity, as spine surgeries have been performed in the absence of general or neuraxial anesthesia. Paraspinal techniques include the ESP, thoracolumbar interfascial plane (TLIP), transversus abdominus plane (TAP), multifidus cervices plane (MCP), and superficial cervical plexus (SCP) blocks.

The ESP block anesthetizes dorsal rami as injected medication spreads between the transverse process and erector spinae muscle. Bupivacaine, levobupivacaine, or ropivacaine are frequently chosen for this purpose, and some institutions continually infuse medication to improve postoperative pain control (1, 9). Many studies have analyzed patient outcomes after both cervical and lumbar cases with ESP blocks (10–16). Importantly, this modality is associated with decreased postoperative opioid requirements (10, 11, 15). It is also shown to increase time to first administration of rescue analgesia, if needed (12). When patient-controlled analgesia is chosen in conjunction with lumbar ESP blocks, patients use less pain medication and experience less PONV than control groups (14). Other studies have also demonstrated shorter hospital stays in ESP block patients, in addition to improved "quality of recovery-15" scores (13, 16).

To perform a TLIP block, the anesthesiologist injects medication in the plane between the multifidus and longissimus muscle, thereby producing anesthesia 2–3 levels above and below the injection site (1). The TLIP block is effective in reducing postoperative pain, opioid consumption, PONV, and the need for rescue analgesia (17). It has also shown to be superior to simple wound infiltration with local anesthetic (18). In one study specific to percutaneous transforaminal lumbar interbody fusion (TLIF), patients provided with a TLIP block did not require any opioid analgesia (19). In a 2020 randomized controlled trial comparing the ESP block to a modified TLIP block in lumbar discectomy, neither was found to be superior to the other (20).

In situations where anesthesia is needed for cervical spine procedures, MCP and SCP blocks may prove helpful. MCP blocks often employ bupivacaine or ropivacaine acting between the multifidus cervices and semispinalis cervices at approximately the C5 level to produce anesthesia, while SCP blocks require nerve identification through the interscalene groove to anesthetize the anterolateral neck (1).

Increasingly, spine surgeons are using different approaches to the spine, rather than just the traditional posterior approaches. This has some advantages in that it minimizes trauma to the larger stabilizing muscles such as the erector spinae muscles and also affords the ability to avoid previous posterior scar tissue in the cases of revision surgery. For anterior (ALIF) and lateral (LLIF) lumbar interbody fusion procedures, other regional blocks are incorporated to augment pain control. One example is the TAP block, where anesthetic is injected between the transversus abdominus and internal oblique muscle planes (1). A recent retrospective study by Reisener et al. reported that use of the TAP block in ALIF and LLIF procedures was associated with significantly decreased LOS, PONV, and post-anesthesia care unit (PACU) opioid usage under bivariable analysis, and with decreased LOS upon multivariable analysis (21).

The quadratus lumborum (QL) block has also proven useful. This technique involves the injection of ropivacaine or bupivacaine along the muscle via lateral, posterior, or anterior approaches. For the lateral approach, anesthetic medication is deposited along the QL lateral border. The posterior approach involves anesthetic injection along plane between the QL and ESP. Finally, the anterior approach targets the area between the psoas and QL. Together, these approaches generally anesthetize the iliohypogastric and ilioinguinal nerves, with the effect potentially extending as wide as the T7-L2 levels (22). With the ability to target the anterior, lateral, and posterior musculature, the QL block is being increasingly used in circumferential spine surgery, where all three approaches to the spine are employed. In the context of total hip arthroplasty, a meta-analysis by Huda et al. demonstrated improved pain control from 6 to 24 hr postoperatively, in addition to reduced 24-hr opioid use and PONV (23). Some of these findings translated to spinal fusion procedures, where bilateral QL block catheters providing continuous local anesthetic infusion decreased opioid use (24). Although data describing QL block use in spine surgery remains limited, the available studies demonstrate its utility and emphasize the need for further investigation.

4.3. The ideal candidate for spine surgery under regional anesthesia

The process of selecting appropriate surgical candidates is nuanced, and surgical teams are often tasked with considering complex, physiologically taxing procedures for patients with multiple comorbidities. Utilization of regional modalities has proven to mitigate many of the risks associated with GA, and teams from various institutions have published algorithms to help guide the selection of patients for SA versus GA (5, 25–27). A selection algorithm designed to guide surgeons through the selection of their first awake patients has been proposed by Letchuman et al., and includes factors such as patient medical history, surgeon experience, and the nature of the patient's spinal disease. The algorithm was implemented successfully in the first 15 patients at their institution. Specifically, nonobese patients without a history of anxiety or airway compromise with spinal disease below the conus medularis are expected to be excellent candidates for awake surgery (25).

Although guidelines are still under development, current literature has demonstrated that the adoption of RA in spine surgery allows surgeons to operate on both elderly patients who may be at greater risk for postoperative cognitive declines, as well as those with multiple cardiovascular, pulmonary, hepatic, renal, endocrine, and genetic diseases (28–30). RA with intravenous sedation has also been employed in the resection of spine metastases in patients with cancer (31).

In minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) procedures, SA led to a 27% reduction in operating room (OR) time and a 30% reduction in procedure time, both of which were statistically significant (32). Although no statistically significant difference was found in estimated blood loss or mean arterial blood pressure, patients were found to have significantly lower intraoperative heart rates, 3-hr postoperative pain scores, and time to ambulation (32). A separate study that analyzed mean LOS noted how this was also reduced (33). In 2021, Perez-Roman et al. conducted a meta-analysis of data from 3709 patients who underwent lumbar spine procedures, finding significantly shorter anesthetic and OR times, fewer postoperative complications, better pain control, less postoperative blood loss, and decreased cost (34). Additionally, meta-analysis by Urick et al. found that operative time, blood loss, PONV, time spent in the PACU, and hospital LOS were decreased when SA was utilized. SA patients were more likely to have other comorbid conditions too, including respiratory or coronary artery disease

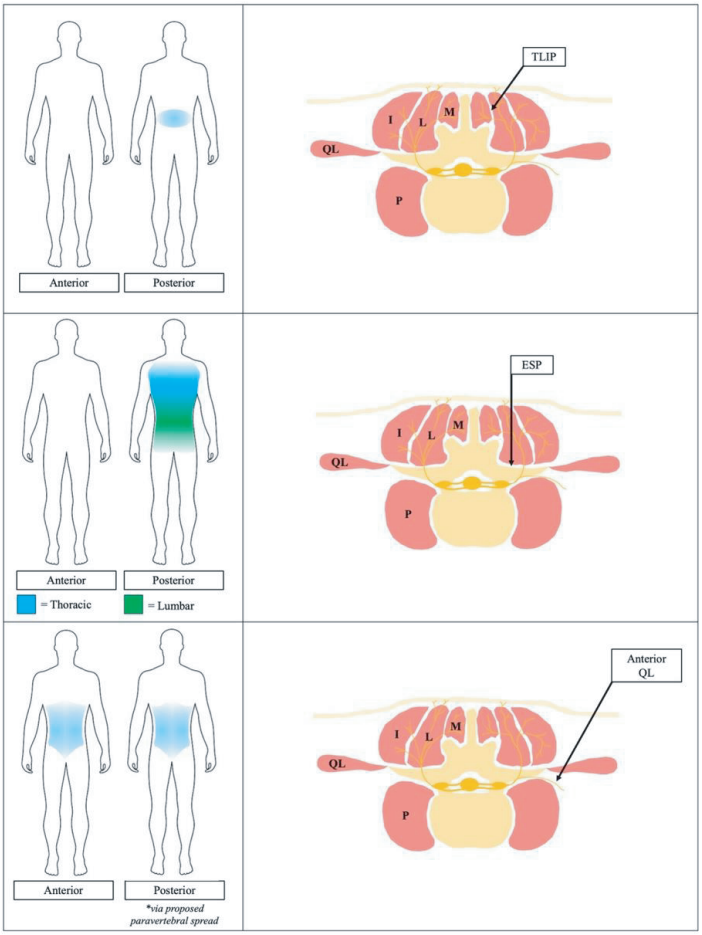

Figure 2. Schematic showing the anatomy of the injection site and area of coverage associated with TLIP, ESP, and QL blocks. A TLIP block placed between the multifidus and longissimus will anesthetize the area 2-3 levels above and below the injection site. In ESP blocks, injected local anesthetic spreads between the transverse process and erector spinae. Both thoracic and lumbar ESP blocks are used, producing anesthesia of dorsal rami. Local anesthetic is deposited along the quadratus lumborum in QL blocks, anesthetizing ventral rami for anterior coverage, while proposed paravertebral anesthetic spread allows for posterior coverage.

(27). Together, these findings suggest that the ideal candidate for an awake procedure under SA may be a surgical patient with a comorbid condition where blood preservation, lower cardiac stress, or decreased operative time and LOS are expected to be of value.

4.4. Success in highly comorbid patients

Several case series have demonstrated great success in pairing regional anesthetic techniques with minimally invasive spine surgery in highly comorbid patients. In a 2022 retrospective case review, awake transforaminal lumbar endoscopic decompressions were performed in 52 patients aged 80 and above. One procedure was complicated by a durotomy and 13.5% required repeat surgery. However, the remaining patients' conditions improved, with their Oswestry Disability Index (ODI) and visual analog scale (VAS) scores for leg pain decreasing from 6.9% and 40.5% to 1.8% and 12%, respectively (35).

Additionally, a 2020 case report describes a 71-year-old male presenting with pain, pseudoarthrosis, and screw loosening after a previous TLIF procedure requiring a revision transforaminal endoscopic discectomy and TLIF. However, this patient was

considered a poor candidate for GA due to an extensive history of cardiac disease. Surgery under local anesthesia (1% lidocaine with epinephrine) with moderate sedation allowed the team to circumvent these risks successfully. The patient's VAS and ODI scores for back pain demonstrated marked improvement (36).

While facet cysts have been considered by some to be a contraindication for RA, another 2022 retrospective chart review analyzed a group of 25 patients with lumbar radiculopathy and facet cysts who underwent awake transforaminal endoscopic resection. The mean ODI and VAS leg pain scores decreased from 39.7% and 7.6% to 13% and 2.3%, respectively, and the authors noted zero complications, readmissions, or recurrence within the two-year follow-up timespan (37).

RA has also been successfully utilized in the operative treatment of lumbar disk pathology in pregnant patients. Although reportedly rare, surgical treatment may be indicated, and maternal distress, radiation exposure, and toleration of prone positioning are considered when deciding between surgical and conservative options (38). In these scenarios, RA may reduce concerns related to airway management, postoperative analgesia, and effects of systemic medication on the fetus (39). This was discussed in a 2021 case report, where a 32-year-old pregnant female with a right paracentral L4-5 disc herniation underwent a microdiscectomy at four weeks gestation. Wishing to avoid medications that could potentially affect fetal organogenesis or induce hypoxia and preterm labor, the team elected to complete the case under local anesthesia with a spinal bupivacaine block. No complications occurred, and the patient remained awake without sedation throughout the procedure. She reported immediate postoperative pain relief (40).

The anticipated procedure length is a major factor in determining whether a patient receives GA or RA. Time-intensive multi-level procedures and those requiring intradural approaches have traditionally precluded the use of intra- or paraspinal blocks as the sole form of anesthetic management (25, 26, 41, 42). However, patients who are at high risk for complications under GA may still require extensive surgical intervention that would typically exceed the time constraints associated with regional blocks. A dual-surgeon "in-parallel" technique was recently described, where minimally invasive TLIF and two-level decompressions were performed simultaneously with two microscopes under SA with a liposomal bupivacaine ESP block. With this approach, the procedure was completed in only 152 minutes. The 87-year-old patient experienced no complications postoperatively, and the initial symptoms had resolved at follow-up (43).

4.5. Perception of regional anesthesia in spine surgery

Conducting spine surgery without GA is becoming more common (44). Despite recent data emphasizing the benefits of operating under RA, some remain hesitant toward adopting these techniques. This idea was illustrated in a 2023 report describing a survey completed by 75 spine surgeons. Less than half of the respondents believed SA was as safe as GA, and 65% cited a lack of established benefit over GA as a reason for hesitancy toward regional modalities (45). Surveys have also been conducted to investigate patients' knowledge of SA. In a report consisting of 50 patient interviews, relatively few patients were aware of regional options in the context of spine surgery, and 60% stated they did not prefer one anesthetic technique over another. However, over half indicated they would be willing to participate in a randomized trial comparing SA to GA (46).

In transitioning one's practice toward a new anesthetic approach, a potential concern amongst surgeons is the rate at which cases are converted from

spinal to general endotracheal anesthesia. Current data suggests that this is relatively rare. However, documented reasons for intraoperative conversion to GA include procedure length, emesis, epistaxis, and anxiety (4, 28). The decision is sometimes made preoperatively, as described by Breton et al. in their retrospective analysis of 343 patients receiving lumbar spine surgery. Two cases total (one fusion and one nonfusion) were converted to GA preoperatively, while none required intraoperative conversion (26).

One institution described how intraoperative conversion events that occurred in their earliest awake cases led to changes in their preoperative medication protocol. For example, they now include ondansetron and glycopyrrolate to mitigate emesis, in addition to oxymetazoline spray to prevent epistaxis (4). This raises the question of whether a "learning curve" is associated with the transition from operating with GA to SA, as well as with the use of minimally invasive surgical techniques (4, 25, 42, 47). West et al. analyzed the proposed "learning curve" idea in single level laminectomy, discectomy, MIS-TLIF, multilevel MIS-TLIF, and robotic MIS-TLIF operations. They measured the length of various procedural segments spanning entry into the OR to discharge and performed a curve-fit regression analysis to determine whether values changed from the first case in the series to the last. From these trends, the authors demonstrated that, in the hands of an experienced surgeon, awake spine surgery is an easily adopted technique (47).

4.6. Considerations for general anesthesia

Contraindications do exist for all anesthetic techniques, and patients in need of operative spine procedures may fall into a "grey area" if they suffer from multiple comorbidities. In recent literature, a BMI >30 kg/m∧2, history of obstructive sleep apnea, and diagnosis of chronic obstructive pulmonary disease have led teams to select GA for their patients out of concern for poor respiratory reserve (25, 42). Conversely, some surgeons attempt to avoid GA in patients with poor cardiopulmonary reserve. This highlights the necessity of a unanimous decision being made by the surgeon, anesthesiologist, and patient when selecting an anesthetic strategy. More relative contraindications may include a history of anxiety, claustrophobia, a significant language barrier, or concerns related to a patient's ability to remain still throughout the length of a procedure (26, 41, 42).

5. Conclusion

RA has created an opportunity to offer spine surgery to patients of advanced age and those with multi-system comorbidities who are not candidates for GA. The practice is growing in popularity, and several techniques are available to provide anesthetic coverage to nearly the entire spine and surrounding structures. Neuraxial techniques such as spinal and epidural anesthesia induce complete anesthesia below a given dermatomal level, and paraspinal techniques such as the ESP, TLIP, MCP, and SCP blocks anesthetize surrounding structures for fusions. For lateral and anterior approaches, TAP and QL blocks have also been employed. These have made fusions, decompressions, and other complex surgical interventions possible under RA.

However, the ideal candidate for awake spine surgery under RA is currently a patient in need of a short, localized operation, or one with multiple comorbid conditions who would be unable to tolerate GA. Importantly, all patients must be amenable to their anesthetic plan to decrease risk of intraoperative conversion to GA. In those who undergo spine surgery with RA, data suggests patients will benefit from reduced procedure length, improved pain control, and greater hemodynamic stability. Patient selection algorithms have been published, and future randomized-controlled trials will allow for

further refinement, providing an exciting avenue for increasing the safety and efficiency of surgical spine interventions.

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None.

6. Conflict of Interest

None.

7. Authors' Contribution

DS, DS, and MA wrote the manuscript. ME, KT, PG, CC, MB, MB, JG, and MA contributed their expertise and provided critical feedback throughout the writing process. MA conceived the idea and supervised the execution of the review.

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